Design and Construction of Base Courses

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Base courses in flexible pavement structures that must carry heavy traffic require certain important considerations in their design and construction that are often neglected. The thickness of these bases are 8 inches to 16 inches, depending upon the type of subgrade on which they rest, which introduces a compaction problem. If the bases are not compacted to a degree equal to that that will be produced by traffic, rough pavements or even failures will be the result. It is also important that during the construction of base courses each layer be dense in order that water from rains will not soften the subgrade. This dense condition is dependent upon the grading of the material and its degree of compaction. The use of calcium chloride in the construction of these bases has proven very advantageous. Calcium chloride also functions as an antifreeze in these base courses which is considered an important advantage in its use.

This paper deals with the North Carolina experience in designing and constructing base courses that are serving as a part of heavy duty pavements. The selection, preparation, and placement of base course materials are discussed as well as certain equipment used in their compaction. The advantages of "stage construction" is discussed and certain important considerations necessary in the use of this procedure mentioned.

● A FLEXIBLE pavement structure usually consists of a surface course composed of asphalt and mineral aggregate and a base course. The base course is generally composed of granular material such as crushed aggregate, gravel, selected soil, or a mixture of selected soil and aggregate. Since the cost of the surface course per ton is several times that of the base course, its thickness is generally just a fraction of the total pavement thickness.

The design of a flexible pavement structure is not unlike the design of a fabricated structure in that the stresses in each member must be determined and each member designed to withstand those stresses. In the case of a flexible pavement, the pressures produced by loads are distributed through the structure to the subgrade. The pressure imposed on the surface or base must not exceed the strength of either or the pavement will fail, and likewise the pressure reaching the subgrade must not exceed its bearing capacity or failure will take place.

The graph in Figure 1 shows the distribution of pressure in soil produced by a dual wheel assembly weighing 10,000 pounds. On the left of the graph is drawn a section of flexible pavement consisting of a 3-inch asphalt surface course on a 14-inch base course. The pressure on top of the surface course is 100 psi., and, assuming that the pressure is distributed through the pavement as it is in soil, the pressure on top of the base and on the subgrade is 78 psi. and 11 psi., respectively. It can be seen that the thickness of the surface course controls the magnitude of the pressure on the base, the thicker the surface, the less the pressure and vice versa. It is obvious that the base course must be constructed of material that is capable of withstanding pressures of 78 psi. and that the subgrade must be composed of soil of such quality and be so prepared as to withstand, without failure, pressures of at least 11 psi.

One important factor in flexible pavement design that is not often mentioned and which could be the cause of pavement failure if ignored, even when the total thickness of the pavement is sufficient to reduce the pressure on the subgrade to within its bearing capacity, is subgrade flexibility or elasticity. Certain types of subgrade soils are elastic and posses sufficient cohesion to permit rather large deflections under pressures whose magnitude is within their bearing capacity. If the full bearing capacity of such a subgrade soil is utilized in the design of the pavement, its deflection under load could be sufficiently large to cause cracks to occur in the overlying base and surface courses. This is especially true in pavements designed for heavy traffic, because the highly stable surfaces and bases required to withstand the high pressures are not very flexible.

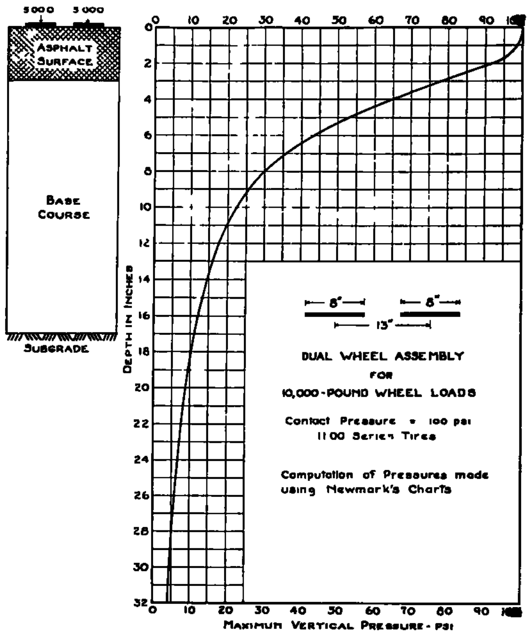

Figure 1. Distribution of pressure in flexible pavements and subgrades.

This problem can be solved by utilizing only a fraction of the bearing capacity of the soil and designing the base and surface courses of material combinations to produce toughness as well as high stability.

It is not intended that this paper be a treatise on flexible pavement design. The author has presented the method of design used by him in another publication (1), however in order to present the full problem of base design, which is part of the subject of this paper, it is necessary to mention certain factors recognized in the design of a flexible pavement. The remainder of the paper will deal with certain types of base courses, the materials they should consist of, the properties of these materials, their production, placement and compaction. The types of bases that will be mentioned are the types used quite extensively in the State of North Carolina in the construction of heavy duty flexible pavements.

BASE COURSES

Two types of base courses will be considered in this paper, the fine aggregate type and the coarse aggregate type. The fine aggregate type material contains less than 35 percent of coarse aggregate (material retained on a No. 10 sieve) and the coarse aggregate type contains from 35 to 70 percent coarse aggregate. Both types of materials are used to construct base courses in flexible pavements designed for heavy traffic, separately or in base and subbase combinations. When the base course is constructed entirely of the fine aggregate type material, the asphalt wearing surface should be 4 inches to 5 inches thick, as may be seen from Figure 1, for the service bearing capacity of fine aggregate type materials is about 50 psi. to 65 psi. The use of the coarse aggregate type material in constructing a base course will produce a base capable of withstanding pressures of 75 psi. to above 100 psi., depending upon the shape and amount of the coarse aggregate. A minimum thickness of asphalt wearing surface may be used on coarse aggregate type base courses, which is generally considered as about 3 inches. When stage type construction is planned, a temporary wearing surface consisting of a bituminous surface treatment mat has been satisfactory on the best coarse aggregate type bases. It is necessary that the wearing surface, whether temporary or permanent, be impervious or the upper portion of the base course will soften during wet periods and cause the surface course to crack or come off under the action of traffic.

Bases and subbases used in heavy duty flexible pavements must be constructed of materials that will be stable under the conditions that prevail during the service life of the pavement. Materials that contain relatively high percentages of silt and clay are capable of absorbing water in an amount sufficient to cause loss of stability. Such materials would be very unsatisfactory for base or subbase courses in humid regions. Also, in localities where the temperatures become low enough to cause frost action, materials high in minus No. 200 sieve material are unsatisfactory. Although the coarse aggregate fraction of a coarse aggregate type base is not subject to traffic abrasion and therefore need not show as low a loss from a wear test as aggregates used in surface courses, the aggregates for bases should not degrade appreciably from handling, nor should they disintegrate from freezing and thawing and wetting and drying.

In certain localities base course materials occur naturally as topsoil or deposits of sand clay, sand clay-gravel, and sand. They may occur as natural mixtures meeting the requirements, or two or more materials may have to be combined to produce mixtures that meet the requirements. In this paper such materials will be designated as soil type base course materials. In localities where soil type base course materials are not available, base course materials are produced from crushed stone, crushed slag, or gravel with or without soil admixture. Such base course materials will be called graded aggregate base course materials in this paper.

SOIL TYPE BASE COURSE MATERIALS

Topsoil selected for use as a base course material is found in open fields and occurs at depths ranging from about 6 inches to 18 inches. Areas where the layers of suitable soil are less than 6 inches thick are avoided as removal of the soil is quite difficult without it becoming mixed with the underlying, generally highly plastic subsoil. Topsoil occurring in wooded areas cannot be obtained without subsoil contamination because of the necessary grubbing operations, and for this reason this type of material must always be taken from open fields. The use of topsoil as a base course material is beginning to be looked upon with disfavor due to the fact that fields robbed of their topsoil are rendered almost useless for agricultural purposes. Sand clay, sand clay-gravel, and sand deposits are usually several feet in depth and yield a comparatively large volume of material per unit of area, which makes them a more desirable source of material. Also, deposits of sand clay, sand clay-gravel, and sand may be located in wooded areas which eliminates the necessity of appropriating cultivated land.

The relatively shallow depths at which topsoil occurs requires careful removal to prevent, as mentioned before, contamination with the subsoil. The use of elevating graders have proved very satisfactory where the thickness of the topsoil is fairly uniform. The soil may also be windrowed with motor graders and then picked up and placed in trucks with loaders and power shovels. This latter method of removing and loading topsoil is the most popular as the equipment used is part of regular grading equipment. Removing topsoil from fields when the subsoil is saturated and soft is likely to cause the topsoil to become contaminated even when light equipment is used. Heavy equipment such as pans, scrapers, bulldozers, etc. should not be used to remove topsoil as their operation is too crude for the care required.

Sand clay, sand clay-gravel, and sand should be excavated with equipment capable of removing the material in lifts from bottom to top. This type of removal is necessary due to the fact that most deposits are stratified and the materials in the strata differ. Excavating the material from bottom to top mixes the soil in the various strata and produces a more or less uniform material. Also, when the material is located, it is sampled by borings which produces samples that are composite mixtures of the various layers as they occur in the deposit, and by excavating the material in the manner prescribed, the resulting mixture represents, more or less, the material as sampled.

In most instances deposits of sand clay and sand clay-gravel are overlain with an entirely different soil. If the overburden is sand, and the underlying material requires an admixture of sand to reduce its plasticity or to improve its grading or both, and the sand is suitable for this purpose, the sand is removed separately and placed on the subgrade at the thickness required. The sand clay material is then excavated and placed on top of the sand layer at the thickness required, and both layers mixed. When the overlying soil is not needed as an admixture or is unsuitable, it is removed and wasted or used in the formation of embankments.

Soil type base course materials commonly occur in nature as the fine aggregate type, having less than 35 percent of coarse aggregate (material retained on a No. 10 sieve), however certain areas do yield the coarse aggregate type. As stated before the materials do not always occur as natural mixtures, but quite often the materials from two or more deposits must be combined to produce the mixture desired. An extract from the North Carolina specifications for soil type base course materials is quoted below:

"Soil type base courses shall be classified as fine aggregate type, Type A, or coarse aggregate type, Type B. The use of either type will be permitted unless otherwise specified. Each type shall be as hereinafter provided, and shall comply with physical requirements as designated below. The base course material shall be free from vegetable matter and lumps or balls of clay, and shall meet the requirements for one of the gradings given below, using AASHO Method T 88.

"Type A. The fine aggregate type shall not contain more than 35 percent of aggregate passing the 2-inch and retained on the No. 10 sieve, and its soil mortar (material passing the No. 10 sieve) shall conform to the following grading requirements:

Sieve Designation	Percentage by Weight Passing
No. 10	100
No. 40	40-75
No. 200	12-35

"The fraction passing the No. 200 sieve shall be less than ⅔ the fraction passing the No. 40 sieve. The material passing the No. 40 sieve shall have a plasticity index not greater than 6 and a liquid limit not greater than 25, when tested in accordance with AASHO Methods T 89, T 90, and T 91.

"Type B. The coarse aggregate type shall contain at least 35 percent of aggregate retained on the No. 10 sieve, and shall conform to the following requirements, using AASHO Method T 88:

Sieve Designation	Percentage by Weight Passing
2-inch	100
1-inch	70-100
½-inch	55-100
No. 4	40-80
No. 10	30-65
No. 40	15-45
No. 200	5-25

"The fraction passing the No. 200 sieve shall be less than ⅔ of the fraction passing the No. 40 sieve. The material passing the No. 40 sieve shall have a plasticity index not greater than 6 and a liquid limit not greater than 25, when tested in accordance with Methods of the AASHO T 89, T 90, and T 91."

As stated before, soil type base courses constructed of fine aggregate type materials require an asphalt wearing surface of from 4 inches to 5 inches due to their lower bearing capacity. In localities where the frost penetrates to depths greater than 4 inches to 5 inches, it is not advisable to use this type of material. The material is suitable in a subbase, provided its elevation is below the frost line. In localities where the frost penetrates to depths greater than the thickness of the asphalt wearing surface, soil type base courses constructed of the coarse aggregate type materials may be used provided the maximum amounts of material allowed to pass the No. 40 and No. 200 sieves are restricted to 30 percent and 10 percent, respectively.

GRADED AGGREGATE BASE COURSE MATERIAL

Graded aggregate base course materials are manufactured materials and for this reason can be designed to meet very rigid requirements. They are made from crushed stone, crushed slag, or crushed and uncrushed gravel with the natural fines produced by crushing, and added fines, if required. While it is permissable to use the run-of-the-crusher material (coarse aggregate with the natural fines present) in the manufacture of graded aggregate base course material, much better control is possible when the crushed material is screened into two sizes, plus No. 4 sieve material and minus No. 4 material. When the run-of-the-crusher material is not separated in two sizes, coarse and fine, extreme care in handling the material is necessary in order to avoid segregation. It is possible, when the run-of-the-crusher material contains sufficient fines, to add moisture to the material as it leaves the screens and stockpile it in such a manner that it can be loaded in trucks with a power shovel. However, most crushed material as produced is deficient in minus No. 4 material and this component must be added. The added material may be suitable soil or stone screenings.

The crushed material, with or without the natural fines present, and the added fines are fed into a pugmill mixer and there the materials are mixed. During the mixing operation, sufficient water is added to produce a more or less plastic mass, which reduces segregation of the aggregates in the mixture and facilitates the compaction of the material after it is spread on the road. Calcium chloride, when required, is added to the material at the rate of 7 pounds per ton either just before it reaches the mixer box or during the mixing operation. The amount of moisture desired in the mixture is about, or slightly more than, the AASHO optimum for the material.

As stated before, due to the fact that graded aggregate base course materials are manufactured materials, they can be designed to meet rather rigid requirements. Elsewhere in this paper it was mentioned that bases should possess certain features in order to withstand the pressures imposed upon them. Base courses should be highly stable and possess sufficient rigidity to support the asphalt wearing surface without deflection under loads sufficient to cause cracking. They should not be susceptable to frost action nor should they possess high capillarity. Dense graded aggregate mixtures containing fines of the proper quality and with limited amounts of material passing the No. 40 and No. 200 sieves will comply with these requirements.

There are several methods used for determining the size distribution or grading of aggregates for maximum density. Ideal gradings for maximum density as derived by Fuller, Weymouth, or Talbot are commonly used and, although the methods are different, give gradings that are fairly well in agreement. The writer uses the formula as developed by A. N. Talbot

$$p = \left(\frac{d}{D}\right)^{1/3}$$

in which

p = proportion by weight passing given sieve.
d = size of opening of given sieve.
D = maximum diameter of particle in the mass.

Specifications for the grading of aggregates generally stipulate the maximum and minimum percentages of material allowed to pass certain sieves. When expressed graphically on a semilogarithmic chart, two lines are drawn forming a "grading band" within whose borders will fall the plots of the grading of materials that meet the speci-

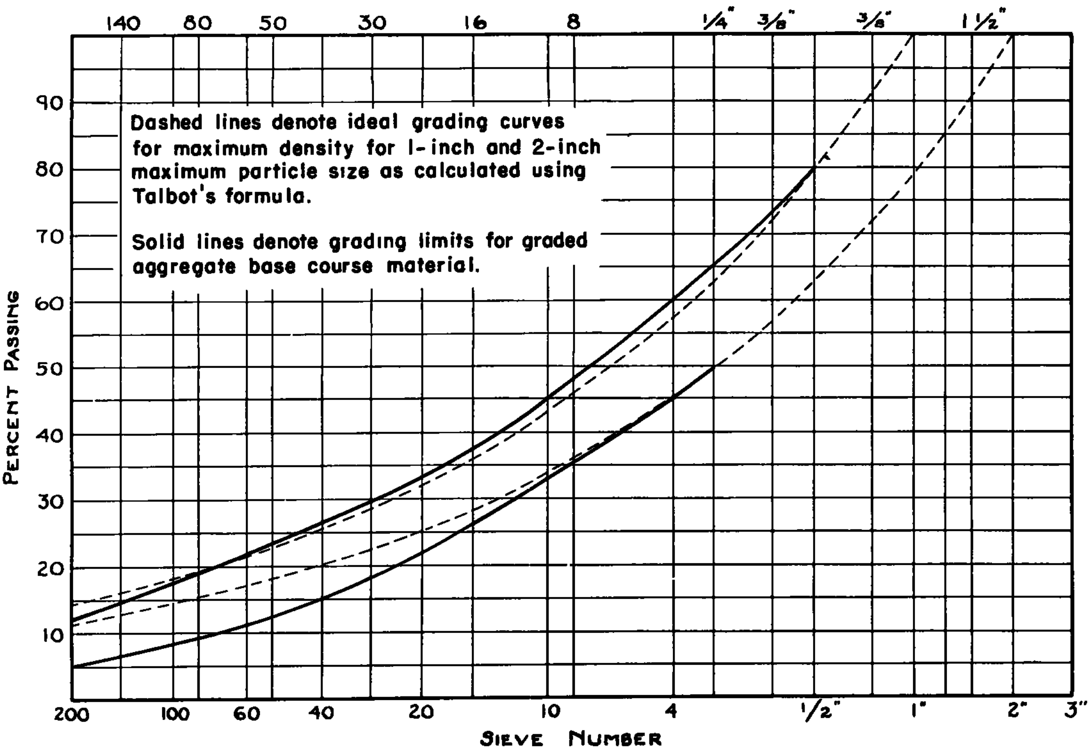

Figure 2.

fications in this respect. Smooth lines will denote uniformly graded materials while broken or "humped" lines denote lack of uniformity.

Figure 2 is a chart showing the "grading band" of dense graded aggregate mixtures designed for use in the construction of bases for heavy traffic. The solid lines denote the grading limits of the mixtures and were drawn by adjusting the dashed lines. The dashed lines were constructed from computations made by the use of Talbot's formula, referred to above, using values of D as one inch for the upper curve and two inches for the lower. Although the two curves drawn with the dashed lines represent ideal gradings for maximum density when the maximum size of particle is one inch and two inches, it is felt that density should be sacrificed slightly to (1) provide a wider grading band below the No. 4 sieve and (2) to reduce the amount of material passing the No. 200 sieve. A wider grading band below the No. 4 sieve is desirable as it allows the use of material from more sources, which, of course, reduces the cost. The minus No. 200 sieve fraction in aggregate mixtures serves to bind the particles together, however, this same material also is highly capillary and is susceptable to frost action. It has been found that mixtures containing more than about 10 percent of minus No. 200 sieve material will lose stability when exposed to freezing and thawing (2). For this reason the limits of the minus No. 200 sieve material are placed as 5 and 12 percent. The maximum passing the No. 200 sieve is placed at 12 percent instead of 10 percent in order to suit more local material. In areas where low temperatures of any duration are prevalent the maximum should be lowered to 10 percent.

If it is practical in the production of graded aggregate base course materials to control the grading of the mixture within very narrow limits, the upper curve in Figure 2 should be lowered. Also, when the aggregate is gravel, the limits passing the No. 4 sieve should be reduced 5 or 10 percentage points. In each instance a mixture containing more coarse aggregate is obtained with ample fines for filling the voids. It is obvious that such a mixture is more stable.

The addition of calcium chloride to graded aggregate base course mixtures is very beneficial. Since the binder fraction of these mixtures is rather low, the base must be kept moist until the surface course is applied, or the material will ravel and pothole under the lightest of local and construction traffic. Mixtures containing gravel as the coarse aggregate fraction are even more difficult to keep bonded, and when the fine component of the gravel mixture is low in minus No. 200 sieve material, calcium chloride is almost a requisite. Although it is permissable, and often necessary, to add water to the base material after it is placed, due to the evaporation of the water incorporated in the mixture at the mixing plant, this operation is an added expense which can be appreciable during dry seasons when the water in local streams is low. Under certain conditions the addition of water to the base course after the materials have been placed can be hazardous to the underlying subgrade soil. Calcium chloride in base course mixtures not only furnishes the moisture necessary to preserve the compacted and bonded state of the base course until the surface course is applied, but, as is generally known, the calcium chloride solution is an aid in the compaction of the base course, since it reduces the compactive effort required.

The presence of calcium chloride in base mixtures is also a protection against frost action. In areas where ice forms on flexible pavements at night and melts during the day, the action of traffic forces small amounts of water through relatively thin wearing surfaces such as bituminous surface treatment mats used as temporary wearing surfaces in stage construction. This water collects on top of the base course, as it is not rapidly absorbed due to the density of the base. The amount of this water is not generally sufficient to cause substantial loss in stability, however, when the tmperature drops during the night, it freezes. Water expands nine percent upon freezing and after several cycles of this action, the swell becomes appreciable. Cracking of the wearing surface and softening of the top portion of the base course follows. Calcium chloride in the upper portion of the base course will lower the freezing point of any water that might be forced through the wearing surface and thereby minimize this type of surface failure.

The cost of calcium chloride is small. In North Carolina the bid prices average about $60 per ton incorporated in the base mixture. It is mixed with the base material at the time it is processed at the rate of 7 pounds per ton. This makes the price $0.011

per square yard-inch of base. If it is used throughout the entire thickness of a 14-inch base course, the cost is $0. 154 per square yard. In most cases calcium chloride is used in the top 3 compacted inches of the base course, which costs $0. 033 per square yard.

BASE COURSE CONSTRUCTION

The proper construction of a heavy duty base course is just as important as the quality of the material or proper thickness. When designing a flexible pavement for thickness, the pavement design engineer selects a subgrade bearing value which is based on tests made on the soils to be encountered at anticipated conditions of moisture and density. These conditions of moisture and density are generally based on data obtained from moisture-density surveys (3) made of pavements serving satisfactorily. It is assumed that the subgrade will be properly drained of surface water and that all seasonal water tables will be lowered by ditches or subdrains to elevations sufficient as not to affect the stability of the subgrade. A subgrade density of at least 95 percent of AASHO density is also expected.

Base courses should never be placed on a soft and yielding subgrade. A soft subgrade is the result of lack of compaction or high moisture content. A spongy subgrade is usually due to wet material beneath the surface, however, highly micaceous soils are spongy wet or dry. Non plastic soils belonging to the A-4 and A-5 subgrade groups are very weak soils regardless of moisture content and should be removed to a depth of at least one foot and backfilled with better material. When this is not feasible, the soils should be stabilized. In North Carolina soils of this type are stabilized by mixing 200 pounds to 300 pounds of crusher-run stone per square yard with the top 3 inches of the subgrade and compacting the mixture at the proper moisture content. If most of the subgrade soils throughout a project belong to the A-4 and A-5 subgrade groups and are non plastic, it might be well to consider the construction of a rigid type pavement rather than a flexible type.

Trench type of construction is used in North Carolina and no provision is made for drainage through the shoulders, except during construction. It is felt that well compacted, dense graded base course material will be unstable if allowed to absorb water in an amount sufficient to cause a drain to function, due to its capillary potential, and that shoulder drains present a hazard in that water from the ditches can enter the base course when they become clogged or are running full during wet periods. A concentrated effort is therefore made to prevent water from entering the base course by the use of more or less impervious wearing surfaces and thoroughly compacting the adjacent 3 feet of the shoulders at the time the base course is compacted. This type of construction has been quite successful in North Carolina and the author is not aware of any pavement failures that could be attributed to trench type of construction. Should edge failures ever develop due to excessive amounts of moisture entering the base course from the shoulders by capillarity, the author would recommend treating the shoulders with bituminous material.

When the rough grading is completed on a project, the subgrade is crowned several inches to provide rapid drainage. Fine grading for the pavement removes this crown which provides material for the construction of the shoulders on each side of the pavement to a depth of about 4 to 6 inches. This is about the compacted thickness of the first layer of the base course. Shoulder material for subsequent layers is obtained from borrow pits, and only sufficient material is placed at the time to construct the shoulders for the particular layer being placed. This construction procedure has several advantages; (1) it keeps the subgrade well above the side ditches, which would not be possible if a trench was cut for the full thickness of a heavy duty base course; (2) it does not require storage of a large volume of soil on each side of the subgrade trench which would prevent drainage of the trench and contaminate the base material; and (3) it allows the shoulders to be thoroughly compacted simultaneously with the base course, which permits more thorough compaction of the shoulder adjacent to the base course and provides better protection to each layer of the base course as it is being constructed.

Soil type base course materials are placed on the prepared subgrade in layers whose loose thickness is such as to permit compaction to a density at least equal to the density produced by the AASHO Compaction Test as modified by the US Corps of Engineers. This loose thickness should not exceed about 8 inches. When the soil type base course material is to consist of a combination of two or more materials, each component is spread on the subgrade in layers of the proper thickness and thoroughly mixed and compacted before subsequent layers are placed. Samples of the mixture are taken at intervals not to exceed 1,000 feet and submitted to the laboratory for tests and approval. Approval of the material is required before placing subsequent layers or applying the surface course.

Compaction of soil type base courses is accomplished by the use of tamping rollers and pneumatic tired rollers. Water is added to the material in an amount necessary for compaction to the density required. The base course is continuously machined with a motor grader during the compaction process in order to obtain the proper cross section and a smooth riding surface, free from waves.

Graded aggregate base course materials are spread on a prepared subgrade with approved mechanical spreaders capable of spreading the material without appreciable segregation. The thickness of the layers is such that thorough compaction to a density at least equal to that obtained by the AASHO Compaction Test as modified by the US Corps of Engineers. This density is furnished the inspector by the laboratory after compaction tests have been made on the material. When compacted to the density required, the material contains 80 to 85 percent solids, depending upon the type of aggregate. Compaction is obtained by the use of pneumatic tired rollers, ring rollers, and recently, vibrating tampers and vibrating rollers.

After each layer of graded aggregate base course material is spread, it should be immediately compacted to the required density. During the compaction process, the material should be continuously machined with a motor grader in order to obtain the proper cross section and a smooth riding surface, free from waves. As before mentioned, shoulder material is placed after the base course layer is spread, and the shoulders are compacted simultaneously with the layer of base course.

At intervals not to exceed 1,000 feet in-place density tests are made on each layer of material. If the proper density has not been secured, the layer is again compacted until this density is obtained. No layer of base course is allowed to be covered with another layer until the lower layer has been checked and approved for density.

The base course is constructed for its full thickness as rapidly as practicable. This is specified in order to afford the subgrade the maximum protection possible. The surface course should also be placed as soon as feasible, especially when practically all traffic cannot be excluded from the base. Generally calcium chloride is specified to be used in the material composing the top layer of the base, although some bases have been constructed with calcium chloride used throughout their full thickness. As stated before the use of calcium chloride is an aid in preventing ravelling and potholing of the base when it is not possible to exclude all traffic, especially with certain materials as gravel and with mixtures containing fines low in minus No. 200 sieve material.

Graded aggregate base course materials are sampled at the plant at the rate of one sample for each 3,000 tons of material produced. These samples are sent to the laboratory for tests. Sufficient sampling and testing is done at the plant to regulate the proportion of fine and coarse material. The amount of moisture is controlled by visual inspection.

The greatest volume of heavy traffic in the State of North Carolina is concentrated in the middle third of the state. With but few exceptions, soil type base course materials are not available locally, so graded aggregate base courses are usually constructed for heavy duty flexible pavements. The normal thickness of these bases ranges from 12 inches to 14 inches, with sections 16 inches to 18 inches in thickness where the quality of the subgrade was poor or questionable. The cost of graded aggregate base courses has been \$1.40 to \$2.00 per square yard for a 14-inch thickness, or \$0.10 to \$0.143 per square yard-inch. These prices are taken from accepted bids on some 340 miles of this type of base, which is the mileage that has been constructed or is under contract since March 1952.

Most of the heavy duty flexible pavements in North Carolina are built using a stage type of construction. Under one paving contract, the base is constructed and surfaced with a temporary wearing surface consisting of a double surface treatment. A year or more later another contract is let for the permanent wearing surface, which consists of 300 pounds of high type plant mix asphalt pavement. Such a construction procedure requires some maintenance of the temporary surface during its use by traffic, but the plan is a sound one from a construction standpoint and has proved quite satisfactory. When the permanent surface course is placed, the riding qualities are excellent and seem to remain so. No surface failures have been observed to date on any of the roads constructed under this plan of stage construction after the permanent wearing surface has been placed.

In this paper the author has mentioned certain problems in the design and construction of base courses used in heavy duty flexible pavements. No attempt was made to cover the design of the entire pavement, although it was necessary to refer to a certain chart used in determining the total thickness of a flexible pavement in order to show the magnitude of pressures reaching the base course. The base course was considered as a member of the pavement structure, and the paper dealt with the selection and design of the materials used in it, their production, placement, and cost in the State of North Carolina.

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